Young open clusters in the Milky Way and Small Magellanic Cloud

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Young open clusters in the Milky Way and Small Magellanic Cloud

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Abstract. NGC6611, Trumpler 14, Trumpler 15, Trumpler 16, Collinder 232 are very young open clusters located in star-formation regions of the Eagle Nebula or the Carina in the MW, and NGC346 in the SMC. With different instrumentations and techniques, it was possible to detect and classify new Herbig Ae/Be stars, classical Be stars and to provide new tests / comparisons about the Be stars appearance models. Special stars (He-strong) of these star-formation regions are also presented.

Keywords. open clusters and associations: individual (Trumpler 14, Trumpler 15, Trumpler 16, Collinder 232), Magellanic Clouds, galaxies: star clusters (NGC346), stars: early-type, stars: pre–main-sequence, stars: emission-line, Be, stars: evolution, ISM: dust, extinction

1. Observations

We used the ESO-WFI (Baade et al. 1999) in its slitless mode (in Halpha, R∼1000) for observing the Galactic open cluster NGC6611, which lies in the Eagle Nebula. This instrumentation allows to disentangle the star with emission-lines from a true circumstellar disk than nebular lines from the diffuse emission of the surrounding nebula. We then observed 100 stars of NGC6611 pre-selected from our WFI catalogue with the VLT-FLAMES/GIRAFFE facilities in MEDUSA mode (Pasquini et al. 2002). About the open clusters Trumpler 14, 15, 16, and Collinder 232, which lie in the Carina region, we pre-selected the B-type stars from our astrophotometric catalogues based on the EIS pre-FLAMES survey images (Momany et al. 2001). We then observed ∼200 of OB-type stars with the VLT-FLAMES/GIRAFFE. We used the LR2, HR4, HR5, HR6, and HR15 settings with resolutions from 6500 to 18000. These setups were chosen for the Balmer lines, Helium I and II lines, Mg II lines, Si III lines. The SMC open cluster NGC346 was observed with the ESO-WFI (Baade et al. 1999) in its slitless mode (in Halpha). More than 50 emission-line stars were found, half of them were detected for the first time, see Martayan et al. (2009).

2. Determination of the interstellar reddening and correction of the magnitudes

To correct the magnitudes of the stars of the interstellar reddening, we measured the equivalent width of interstellar lines at 443.0, 450.2, and 661.3 nm. We then used the calibration from Herbig (1975) to obtain the values of the interstellar reddening E[B-V] for each star observed with GIRAFFE. The map of the reddening for the Trumpler 14, 15, 16 clusters is shown in Fig. 1. From this estimate of the E[B-V], we corrected the JHK

magnitudes from 2MASS as well as the SPITZER magnitudes. However, the SPITZER data are available for the stars in NGC6611 but not for the stars in Trumpler 14, 15, 16, open clusters. Then 2 kinds of dereddened colour-magnitudes diagrams are obtained for NGC6611 (see Martayan et al. 2008) For the Trumpler 14, 15, 16 clusters, the 2MASS-diagram is shown in Fig. 2. The Emission-line stars are indicated by a red triangle. The status of several of them is obvious: clearly PMS or Ms object. However, for the stars located in the intermediate regions, a complementary analysis must be done by using the evolutionary status determined from the fundamental parameters and compared to the age of the open clusters.

3. Fundamental parameters determination

The fundamental parameters were determined by using the GIRFIT code from Frémat et al. (2006). This code fits the observed spectrum with theoretical ones obtained with TLUSTY and SYNSPEC codes from Hubeny & Lanz (1995). For each star member of the open cluster (NGC6611, Trumpler 14, etc), we have obtained its age with theoretical evolutionary tracks from Schaller et al. (1992). Then the age of the open cluster is redetermined using these stars, members of the clusters.

4. Nature of the emission-line stars

In order to determine the exact nature of emission-line objects in NGC6611, Trumpler 14, Trumpler 15, Trumpler 16, Collinder 232, we combined the different parameters from the colour-colour diagrams and from the evolutionary status determined via the HR evolutionary tracks.

-if the star is located in the "box" of Herbig Ae/Be star from Hernández et al. (2005) in the dereddened 2MASS diagram, then the star is a pre-MS star.
-if the star is located in the class II or class I areas in the SPITZER diagram, then the star is a pre-MS star.
-if the star is located in an intermediate region, the evolutionary status obtained from the fundamental parameters combined to the membership of open clusters must be taken into account:
* star member of the open cluster, with an age equivalent to the open cluster => MS

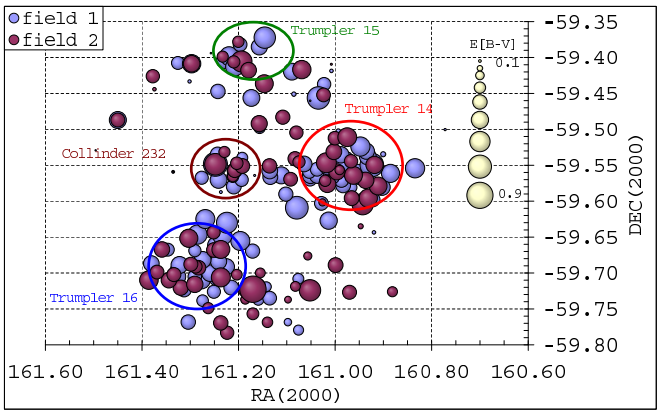

Figure 1. Map of the interstellar reddening in the Carina region for stars observed in Trumpler 14, 15, 16, and Collinder 232.

star
* star member of the open cluster, with an age apparently older than the cluster => pre-MS star
* star not member of the open cluster => status not certain
-if the star is not present in the boxes of pre-MS star and its evolutionary status compatible with the age of its hosting open cluster, then the star is probably a classical Be star (with a decretion disk vs. an accretion disk in case of pre-MS star like Herbig Ae/Be stars). All the details about NGC6611 can be retrieved from Martayan et al. (2008).

5. Special stars

Among the emission-line stars of NGC6611, 2 are of special interests, the first one is W601, which was found to host a magnetic field by Alecian et al. (2008). They also found that this star is also an He-strong star. Thanks to VLT-GIRAFFE observations of W601 and W080, it was possible to compare the spectral features of these 2 stars. We found that W080 is like a spectral twin of W601 and then is probably also an He-strong star. Moreover, its broad, deep spectral lines cannot be reproduced by the models (Martayan et al. 2008). In order to find if W080 hosts a magnetic field like W601, two sets of observations were performed at the CFHT with the ESPADONS spectropolarimeter. However, the faintness of W080 implies that this star is at the limit of the capabilities of this instrumentation. The preliminary results seem to show no strong magnetic field in W080, however, the data are currently analysed to find a potential weaker magnetic field and/or to provide the upper estimates of its intensity as well as the confirmation of its He-strong status.

6. Conclusions

We found 11 emission-line star in NGC6611 and its vicinity, 9 of them are new Herbig Ae/Be stars. In the open clusters Trumpler 14, 15, 16, Collinder 232 and their vicinity in the Carina nebula; 6 of the 16 emission-line stars seem to be Herbig Ae/Be stars. For the 10 of the remaining emission-line stars: the status is uncertain for 2 of them, and 8 of them are probably main sequence stars so are classical Be stars. In NGC346,

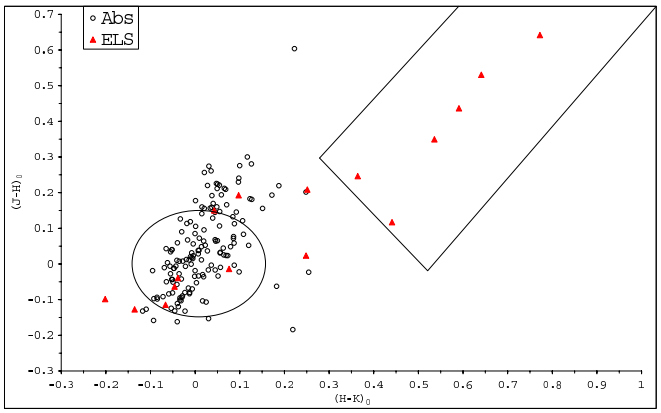

Figure 2. Dereddened 2MASS colour-colour diagram for stars observed in Trumpler 14, 15, 16, Col232 open clusters. The large rectangular area from Hernández et al. (2005) corresponds to the area of PMS objects like Herbig Ae/Be stars.

complementary observations at higher spectral resolution are needed for determining the exact nature of the 50 emission-line stars found.

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